

What Is Claimed Is:

1. A light emitting diode, comprising:
 - a transparent insulating substrate;
 - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
 - an InGaN light-emitting layer directly over said lower cladding layer;
 - a second conductivity type GaN as second upper cladding layer directly over said InGaN light-emitting layer;
 - a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
 - an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
- 10 15 a first electrode formed on the partially exposed area of the first conductivity type GaN; and
a second electrode formed on top of the light transmitting layer.
2. A light emitting diode as recited in claim 1, wherein said transparent conducting oxide (TCO) has the composition:
 - 20 $\text{Al}_x\text{Ga}_{3-x}\text{In}_{5+y}\text{Sn}_{2-z}\text{O}_{16-2z}$,
Where $0 \leq x < 2$, $0 < y < 3$, $0 \leq z < 2$.
 3. A light emitting diode as recited in claim 1, wherein said transparent insulating substrate is selected from a group consisting of Al_2O_3 , LiGaO_2 , LiAlO_2 and MgAl_2O_4 .
 - 25 4. A light emitting diode as recited in claim 1, wherein said GaN based

contact layer is selected from a group consisting of AlGaN, GaN, and InGaN.

5. A light emitting diode, comprising:
 - a first conductivity type substrate;
 - 5 a first conductivity type GaN as a first lower cladding layer directly over said substrate;
 - an InGaN light-emitting layer directly over said lower cladding layer;
 - a second conductivity type GaN as a second upper cladding layer directly over said InGaN light-emitting layer;
- 10 a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
 - an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
 - 15 a first electrode formed underneath the first conductivity type substrate; and
 - a second electrode formed on top of the light transmitting layer.
6. A light emitting diode as recited in claim 5, wherein said transparent
- 20 conducting oxide (TCO) has the composition:

$\text{Al}_x\text{Ga}_{3-x-y}\text{In}_{5+y}\text{Sn}_{2-z}\text{O}_{16-2z}$,
Where $0 \leq x < 2$, $0 < y < 3$, $0 \leq z < 2$.
7. A light emitting diode as described in claim 5, wherein said conductivity type substrate is selected from a group consisting of SiC, Si, ZnSe, GaAs,
- 25 GaP, GaN and AlN.

8. A light emitting diode as described in claim 5, wherein said GaN based contact layer is selected from a group consisting of AlGaN, GaN, and InGaN.
 9. A light emitting diode, comprising:
 - 5 a transparent insulating substrate;
 - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
 - an InGaN light-emitting layer directly over said lower cladding layer;
 - a second conductivity type GaN as second upper cladding layer directly
 - 10 over said InGaN light-emitting layer;
 - an AlGaInN system intermediate layer directly over said upper cladding layer, with material band-gap energy is lower than the second conductivity type GaN and thickness is between 5 Angstroms to 500 Angstroms;
 - a GaN based contact layer with Gallium rich phase and thickness is
 - 15 between 5 Angstroms to 1000 Angstroms directly over said intermediate layer;
 - an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
 - 20 a first electrode formed on the partially exposed area of the first conductivity type GaN; and
 - a second electrode formed on top of the light transmitting layer.
10. A light emitting diode as recited in claim 9, wherein said transparent conducting oxide (TCO) has the composition:
- 25 $\text{Al}_x\text{Ga}_{3-x-y}\text{In}_{5+y}\text{Sn}_{2-z}\text{O}_{16-2z}$,

Where $0 \leq x < 2$, $0 < y < 3$, $0 \leq z < 2$.

11. A light emitting diode as recited in claim 9, wherein said transparent insulating substrate is selected from a group consisting of Al_2O_3 , LiGaO_2 , LiAlO_2 and MgAl_2O_4 .
- 5 12. A light emitting diode as recited in claim 9, wherein said GaN based contact layer is selected from a group consisting of AlGaN , GaN , and InGaN .
13. A light emitting diode as recited in claim 9, wherein said intermediate layer is selected from a group consisting of AlGaInN , InGaN , and InN .
- 10 14. A light emitting diode, comprising:
 - a transparent insulating substrate;
 - a first conductivity type GaN as a first lower cladding layer directly over said transparent insulating substrate;
 - an InGaN light-emitting layer directly over said lower cladding layer;
 - 15 a second conductivity type GaN as second upper cladding layer directly over said InGaN light-emitting layer;
 - a GaN based contact layer with Gallium rich phase and thickness is between 5 Angstroms to 1000 Angstroms directly over said upper cladding layer;
 - 20 an AlGaInSnO system transparent conducting oxide (TCO) as a light transmitting layer directly over said GaN based contact layer, and the thickness of this TCO thin film must over 5 Angstroms;
 - a transparent conducting oxide window layer directly over said light transmitting layer;
 - 25 a first electrode formed on the partially exposed area of the first

- conductivity type GaN; and
- a second electrode formed on top of the transparent conducting oxide window layer.
15. A light emitting diode as recited in claim 14, wherein said transparent
- 5 conducting oxide (TCO) has the composition:
- $$\text{Al}_x\text{Ga}_{3-x-y}\text{In}_{5+y}\text{Sn}_{2-z}\text{O}_{16-2z},$$
- Where $0 \leq x < 2$, $0 < y < 3$, $0 \leq z < 2$.
16. A light emitting diode as recited in claim 14, wherein said transparent insulating substrate is selected from a group consisting of Al_2O_3 , LiGaO_2 ,
- 10 LiAlO_2 and MgAl_2O_4 .
17. A light emitting diode as recited in claim 14, wherein said GaN based contact layer is selected from a group consisting of AlGaN, GaN, and InGaN.
18. A light emitting diode as recited in claim 14, wherein said transparent
- 15 conducting oxide window layer is selected from a group consisting of SnO_2 , In_2O_3 , ITO, Cd_2SnO_4 , ZnO , CuAlO_2 , CuCaO_2 , SrCuO_2 , NiO , and AgCoO_2 .

20

25